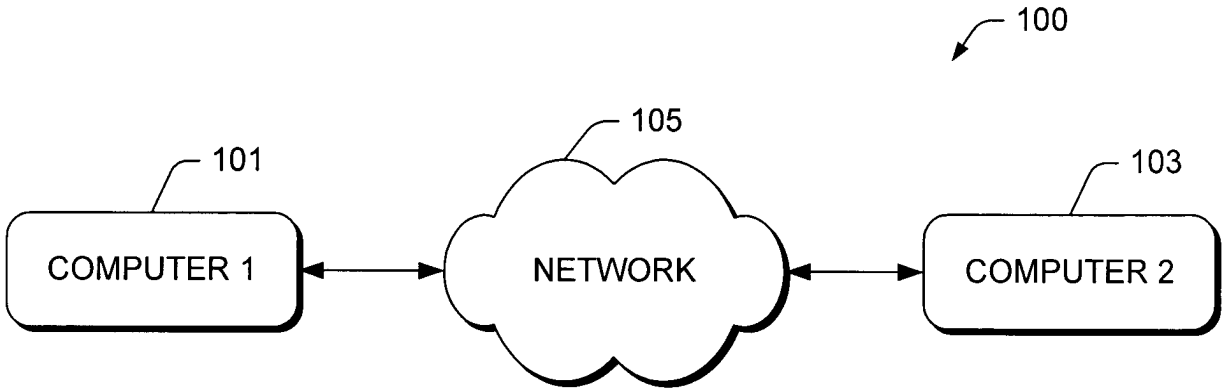
100
105
101
103
COMPUTER 1
NETWORK
COMPUTER 2

FIG. 1

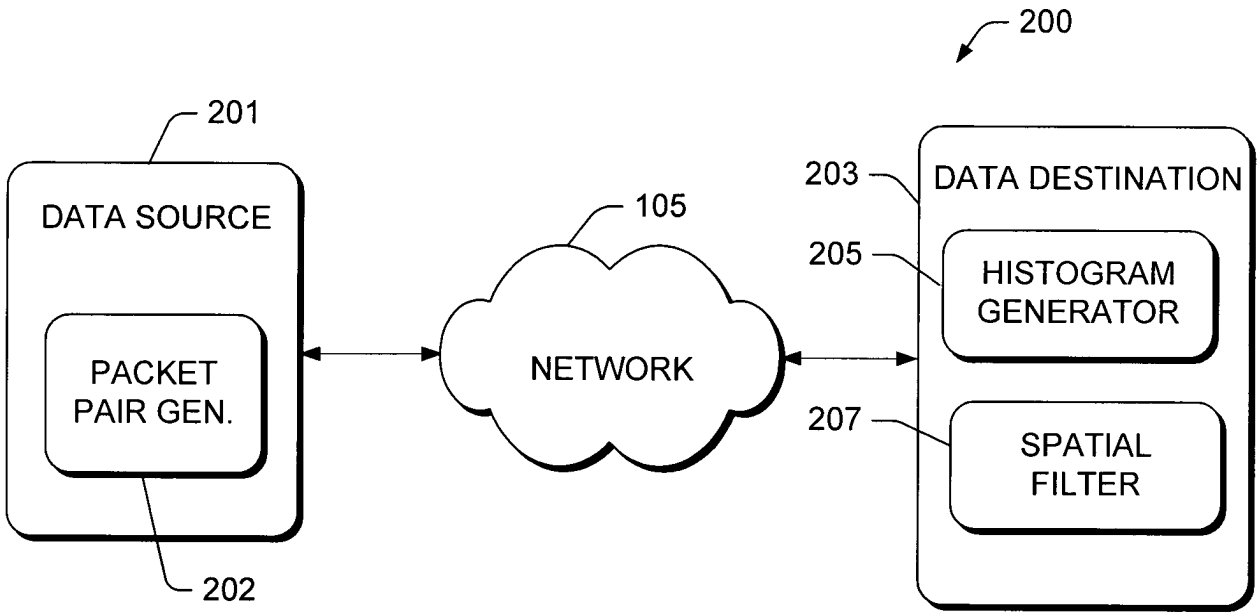
200
201
DATA SOURCE
PACKET PAIR GEN.
202
105
NETWORK
203
DATA DESTINATION
205
HISTOGRAM GENERATOR
207
SPATIAL FILTER

FIG. 2

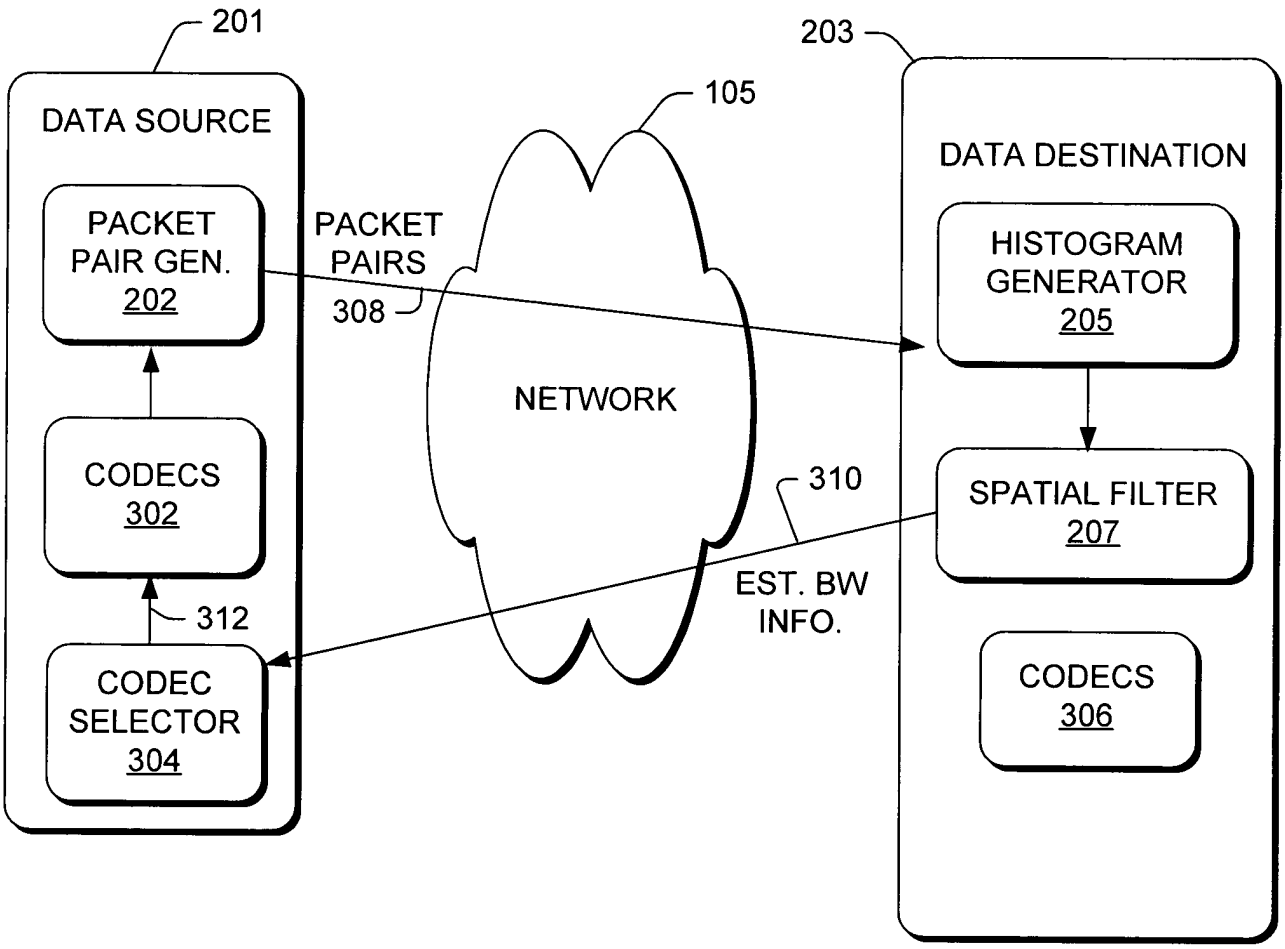
201
DATA SOURCE
PACKET PAIR GEN. 202
CODECS 302
312
CODEC SELECTOR 304
PACKET PAIRS
308
105
NETWORK
310
EST. BW INFO.
203
DATA DESTINATION
HISTOGRAM GENERATOR 205
SPATIAL FILTER 207
CODECS 306

FIG. 3

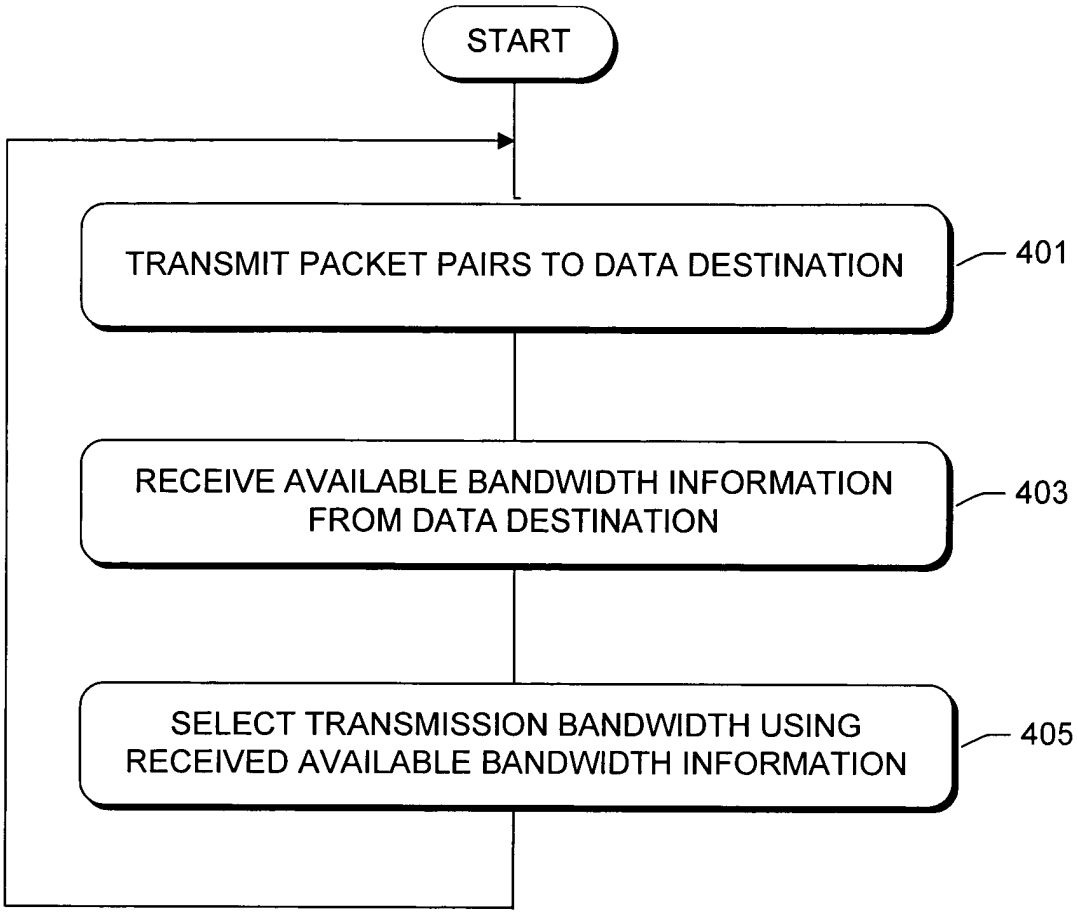
START
TRANSMIT PACKET PAIRS TO DATA DESTINATION
401
RECEIVE AVAILABLE BANDWIDTH INFORMATION FROM DATA DESTINATION
403
SELECT TRANSMISSION BANDWIDTH USING RECEIVED AVAILABLE BANDWIDTH INFORMATION
405

FIG. 4

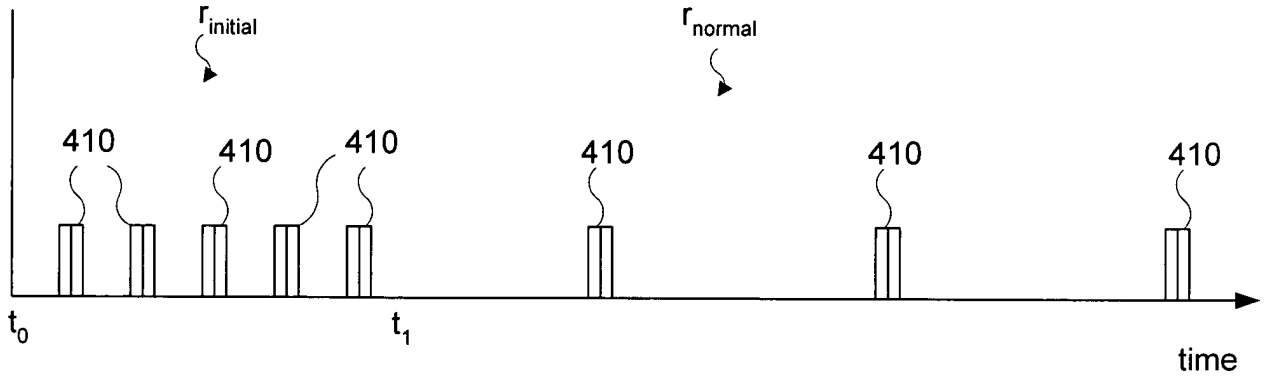
r initial
r normal
410
410
410
410
410
410
t0
t1
time

FIG. 4A

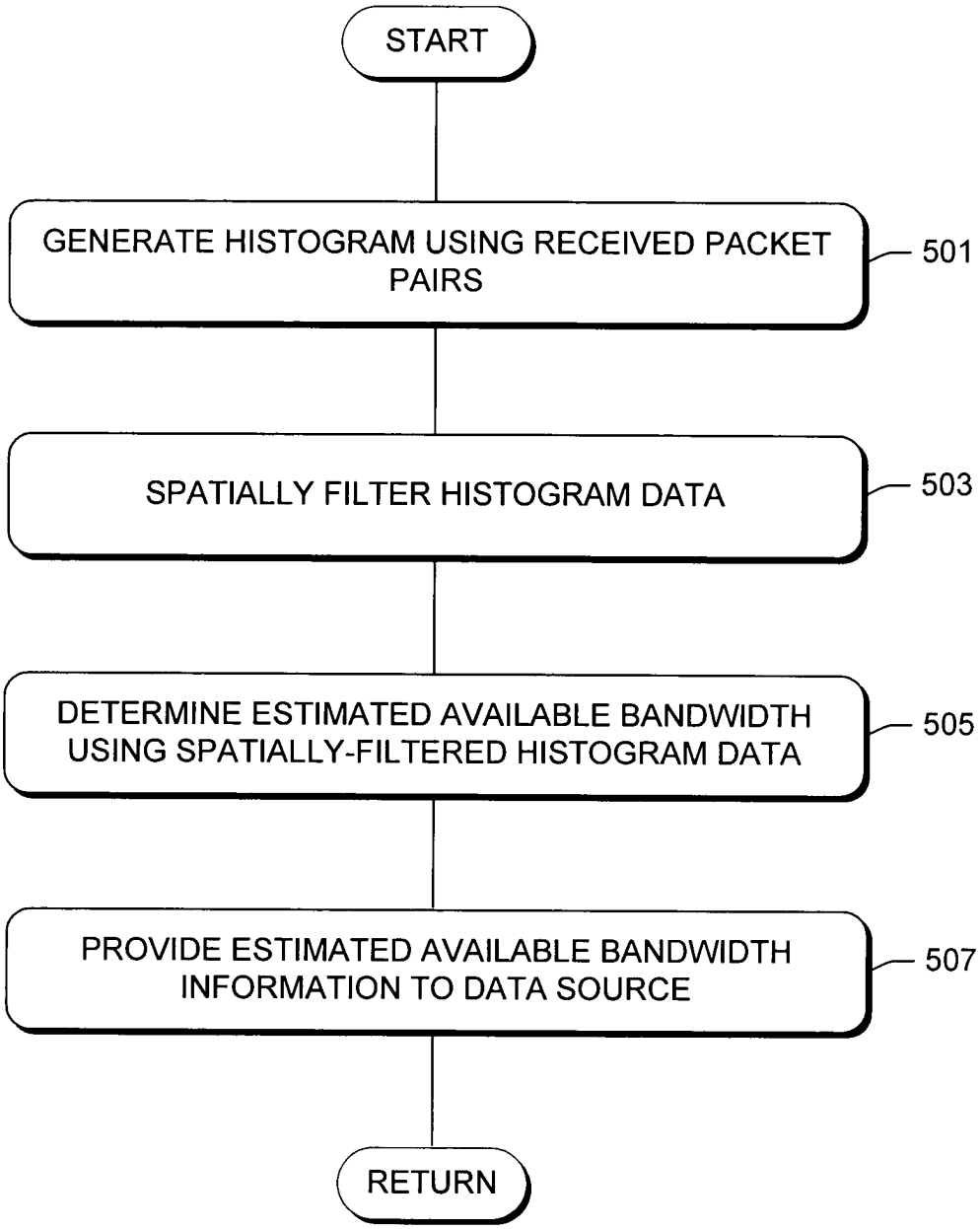
START
GENERATE HISTOGRAM USING RECEIVED PACKET PAIRS
501
SPATIALLY FILTER HISTOGRAM DATA
503
DETERMINE ESTIMATED AVAILABLE BANDWIDTH USING SPATIALLY-FILTERED HISTOGRAM DATA
505
PROVIDE ESTIMATED AVAILABLE BANDWIDTH INFORMATION TO DATA SOURCE
507
RETURN

FIG. 5

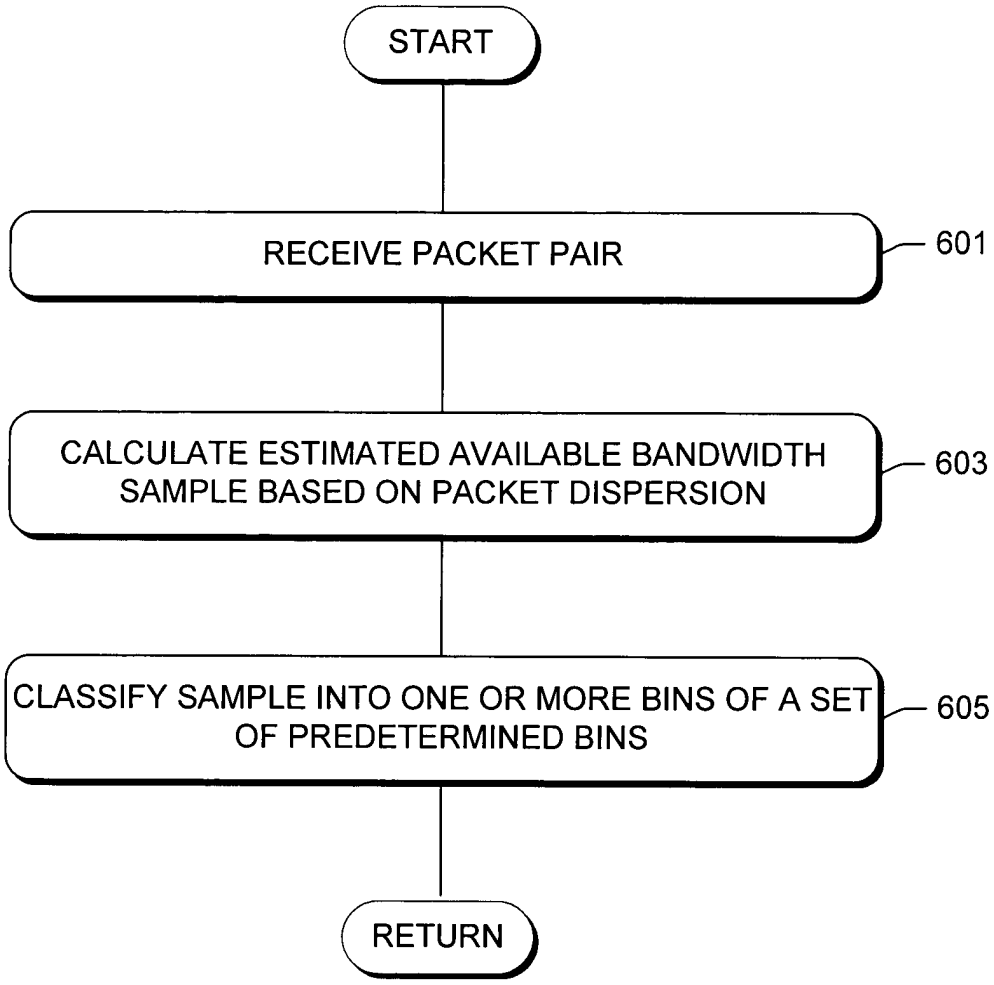
START
RECEIVE PACKET PAIR
601
CALCULATE ESTIMATED AVAILABLE BANDWIDTH SAMPLE BASED ON PACKET DISPERSION
603
CLASSIFY SAMPLE INTO ONE OR MORE BINS OF A SET OF PREDETERMINED BINS
605
RETURN

FIG. 6

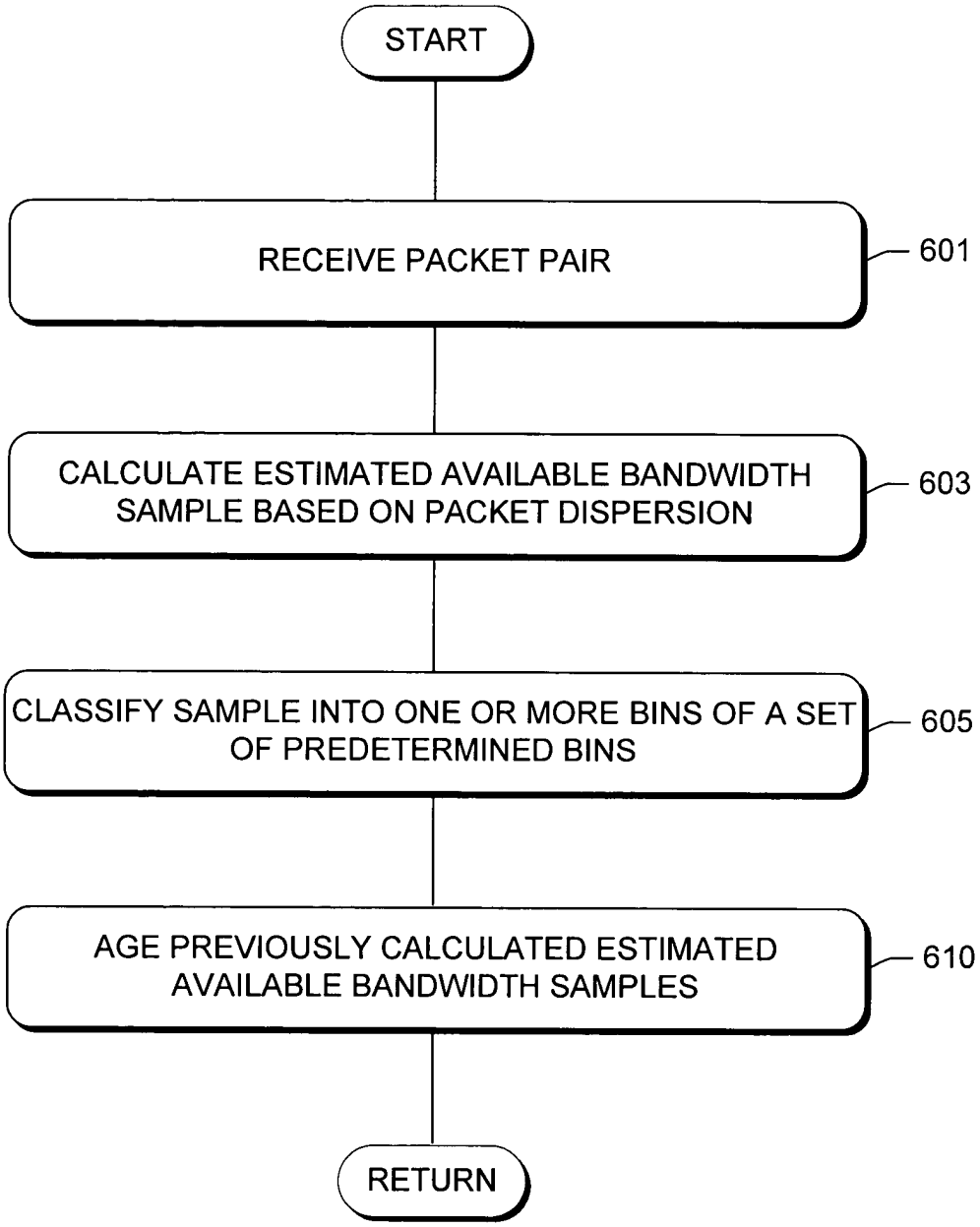
START
RECEIVE PACKET PAIR
601
CALCULATE ESTIMATED AVAILABLE BANDWIDTH SAMPLE BASED ON PACKET DISPERSION
603
CLASSIFY SAMPLE INTO ONE OR MORE BINS OF A SET OF PREDETERMINED BINS
605
AGE PREVIOUSLY CALCULATED ESTIMATED AVAILABLE BANDWIDTH SAMPLES
610
RETURN

FIG. 6A

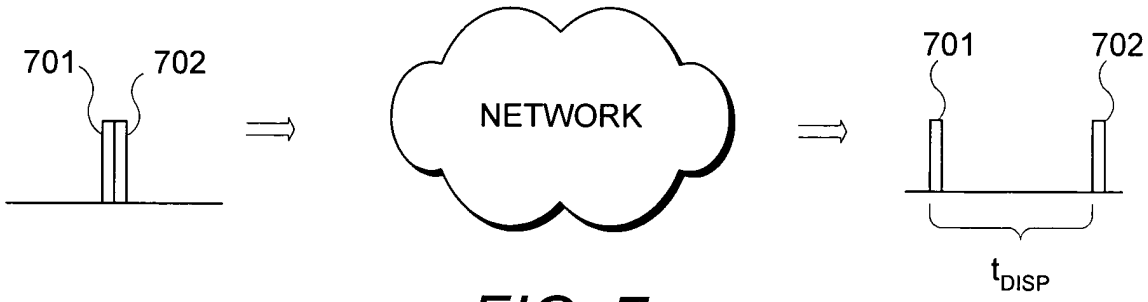
701
702
NETWORK
701
702
t_{DISP}

FIG. 7

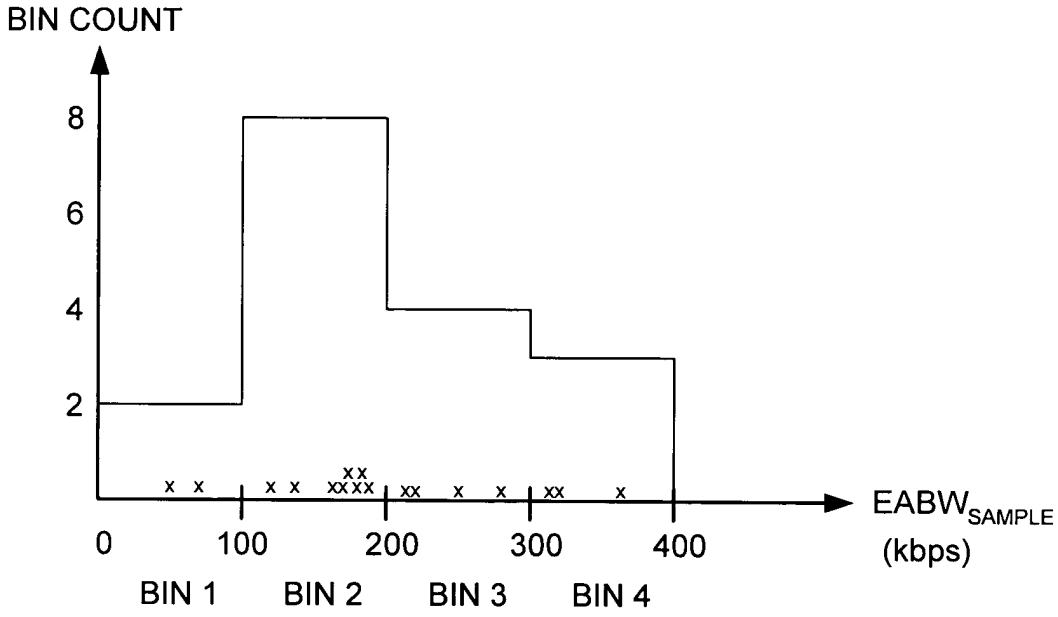
BIN COUNT
8
6
4
2
0
100
200
300
400
BIN 1
BIN 2
BIN 3
BIN 4
$EABW_{SAMPLE}$
(kbps)

FIG. 8

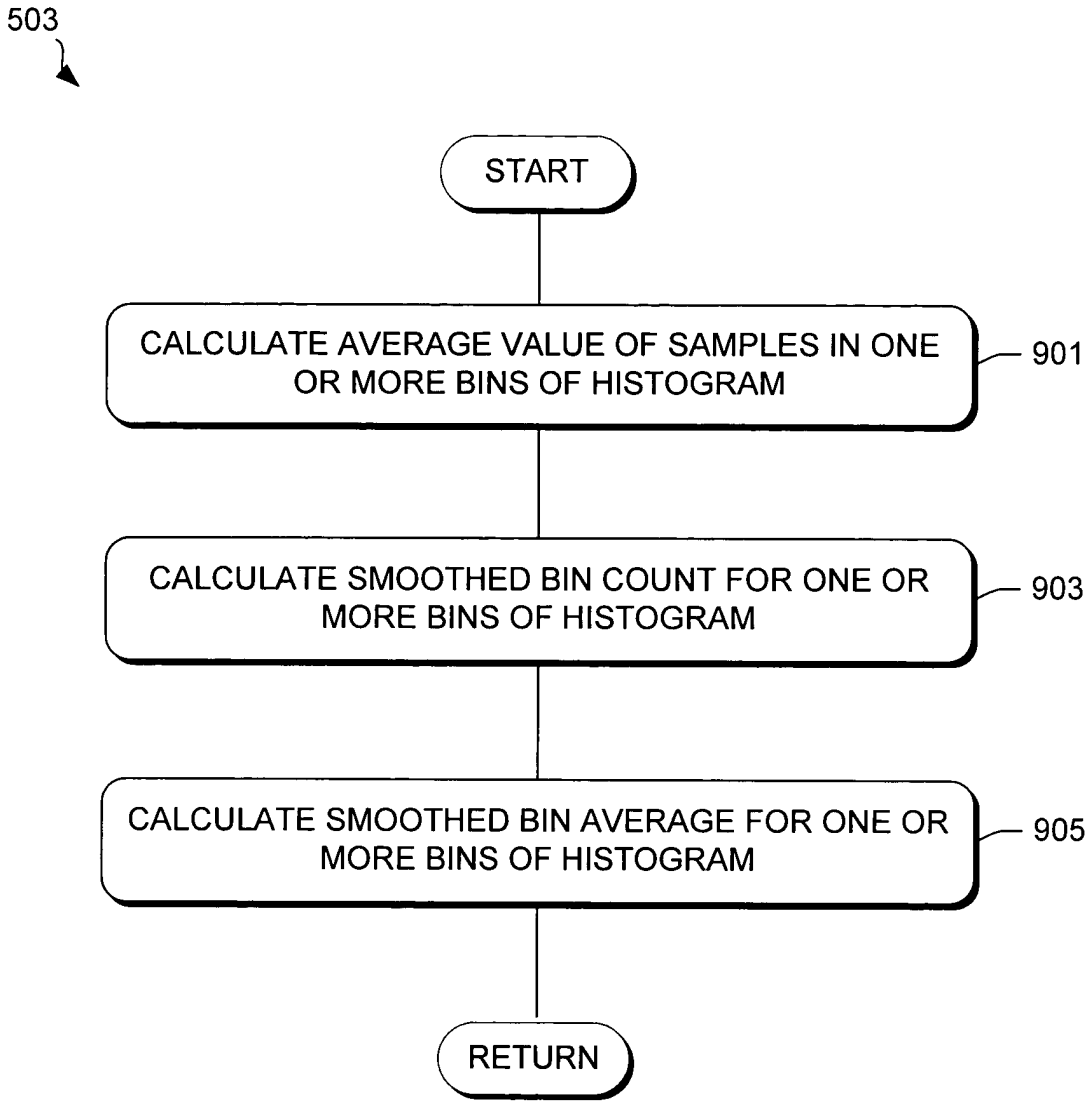
503
START
CALCULATE AVERAGE VALUE OF SAMPLES IN ONE OR MORE BINS OF HISTOGRAM
901
CALCULATE SMOOTHED BIN COUNT FOR ONE OR MORE BINS OF HISTOGRAM
903
CALCULATE SMOOTHED BIN AVERAGE FOR ONE OR MORE BINS OF HISTOGRAM
905
RETURN

FIG. 9

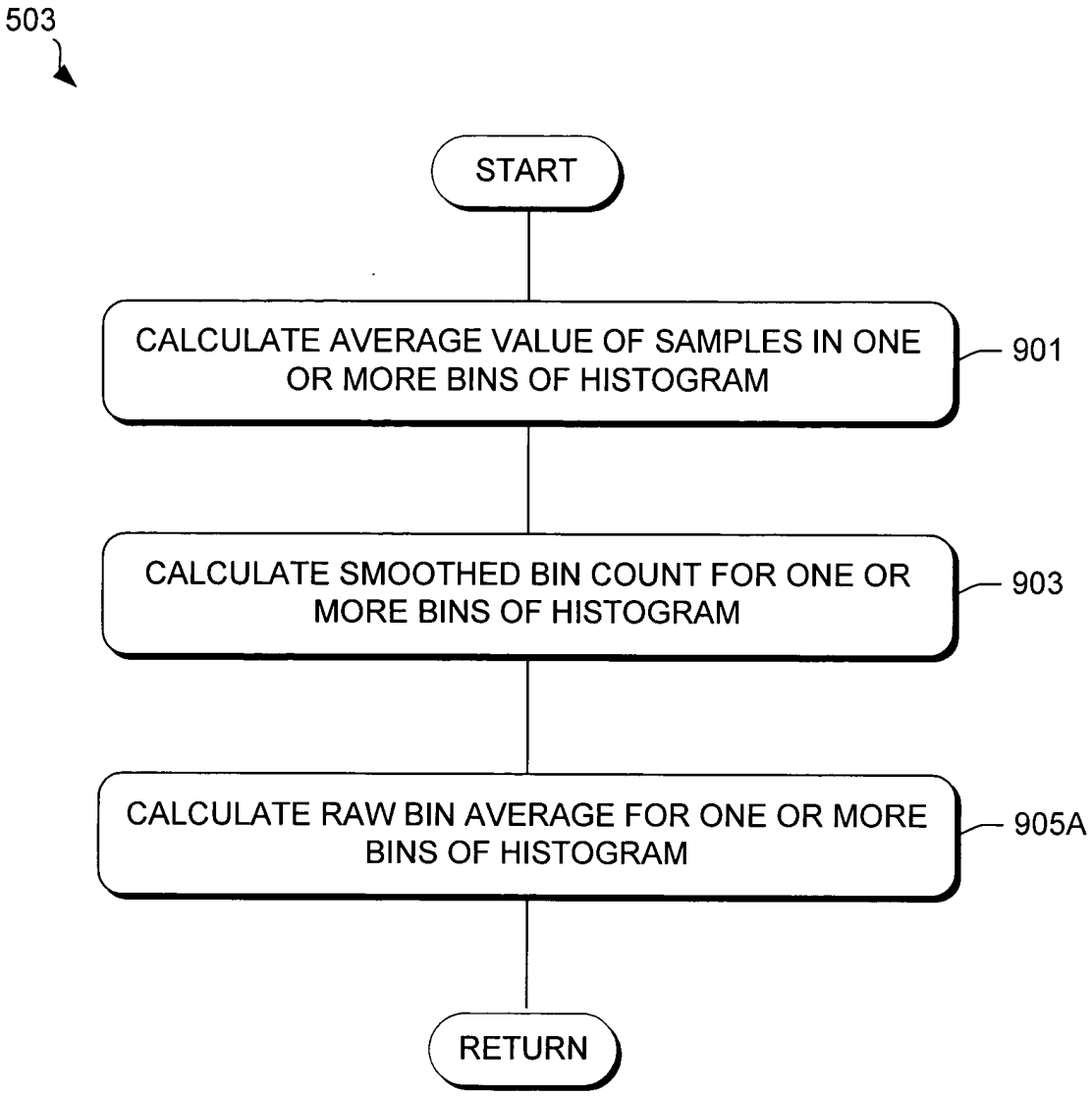
503
START
CALCULATE AVERAGE VALUE OF SAMPLES IN ONE OR MORE BINS OF HISTOGRAM
901
CALCULATE SMOOTHED BIN COUNT FOR ONE OR MORE BINS OF HISTOGRAM
903
CALCULATE RAW BIN AVERAGE FOR ONE OR MORE BINS OF HISTOGRAM
905A
RETURN

FIG. 9A

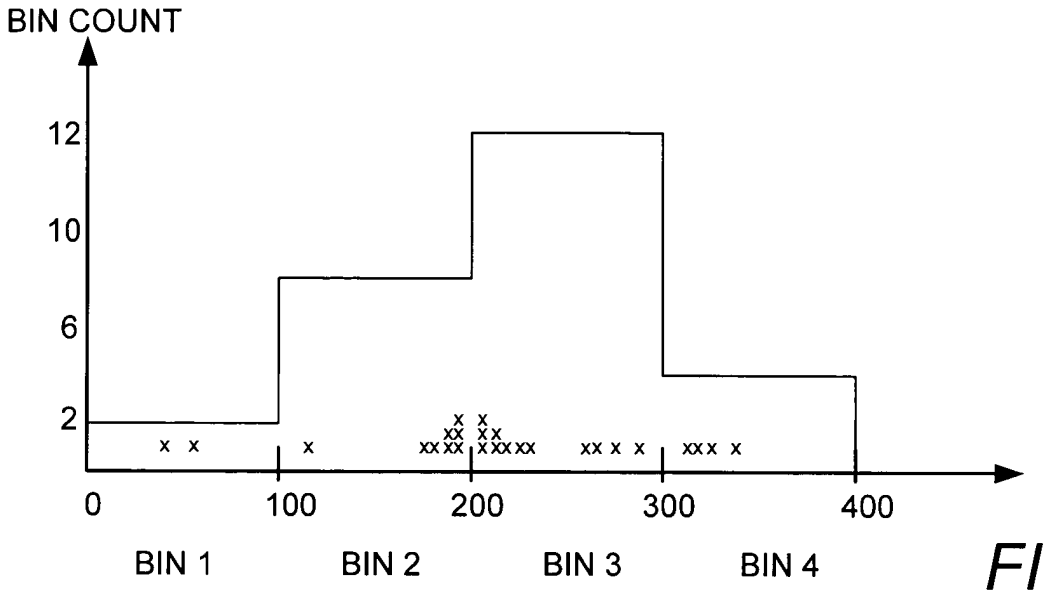

FIG. 10

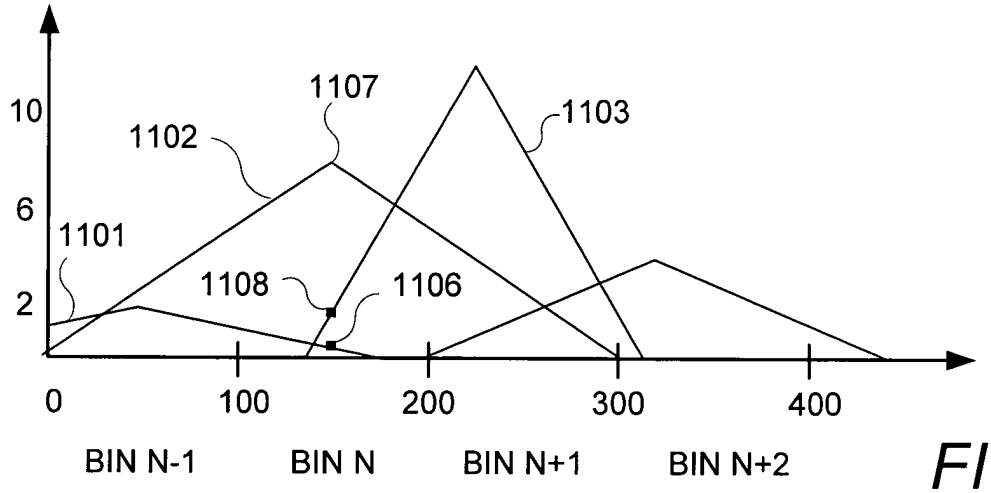

FIG. 11

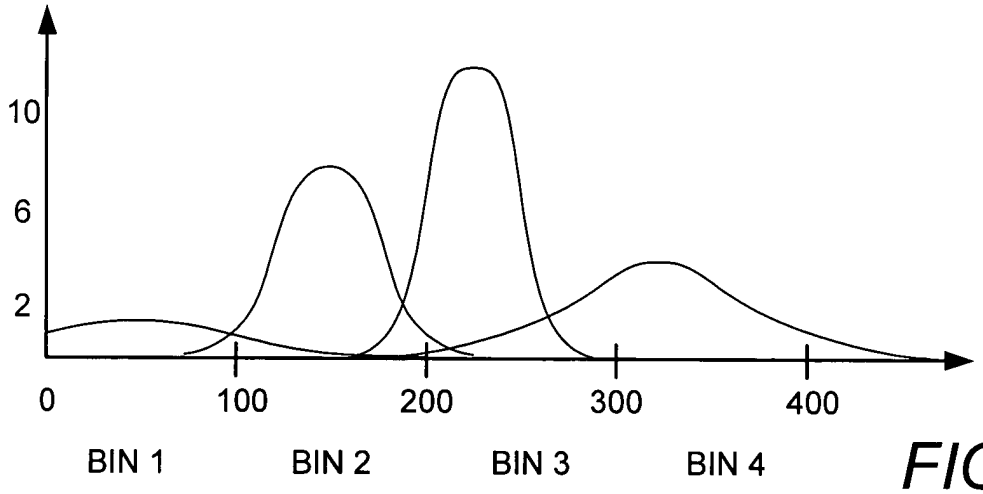

FIG. 11A

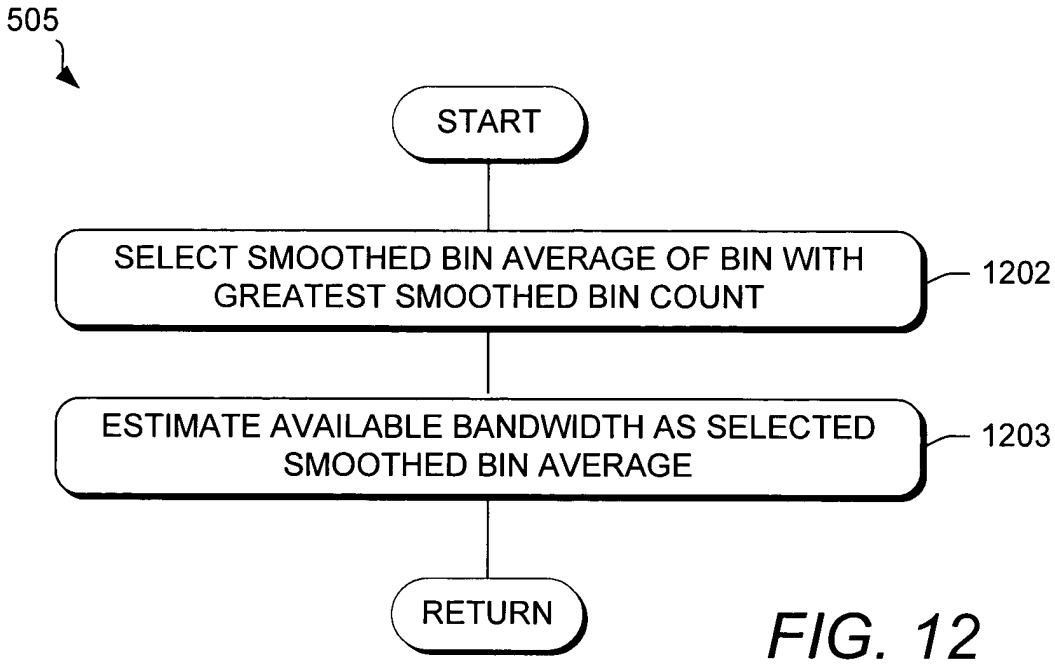

FIG. 12

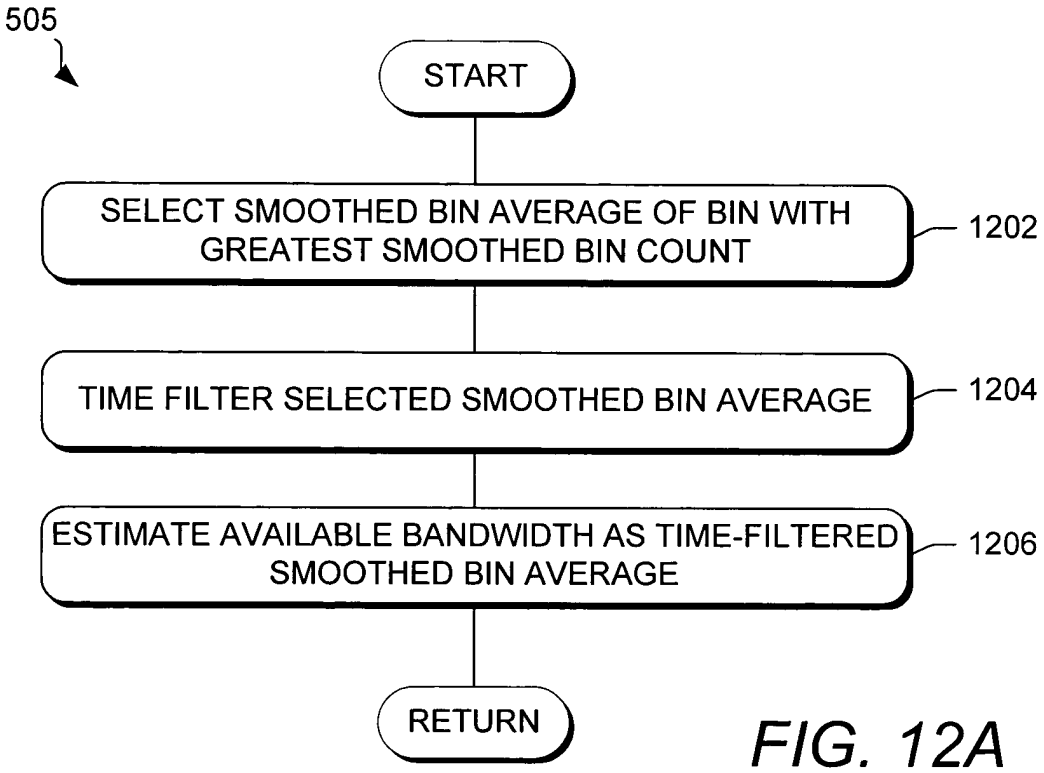

FIG. 12A

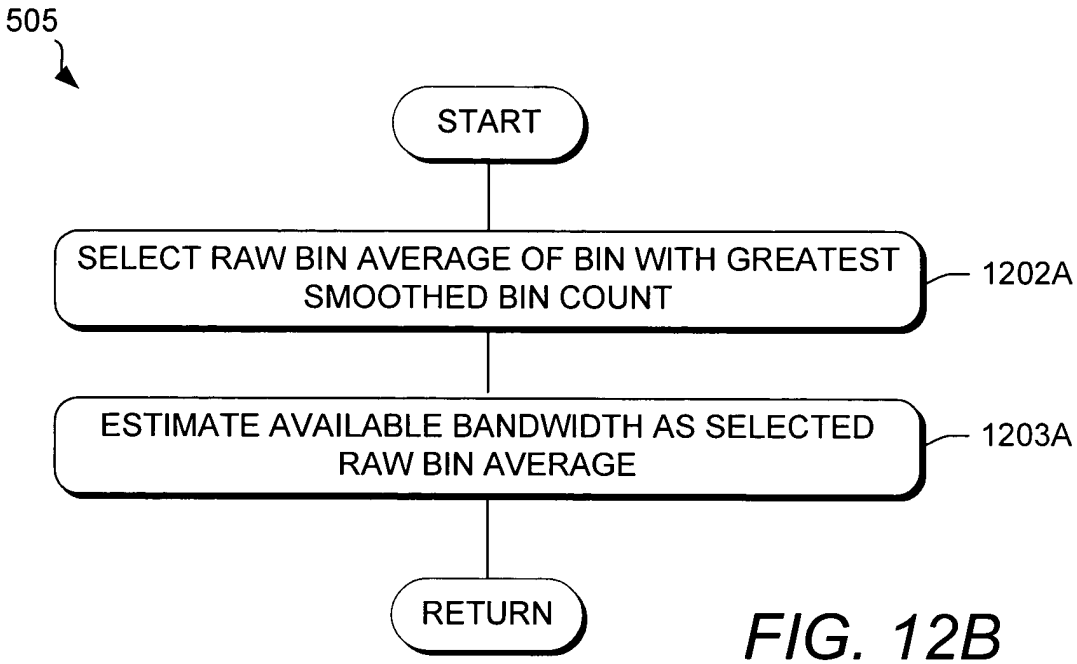

FIG. 12B

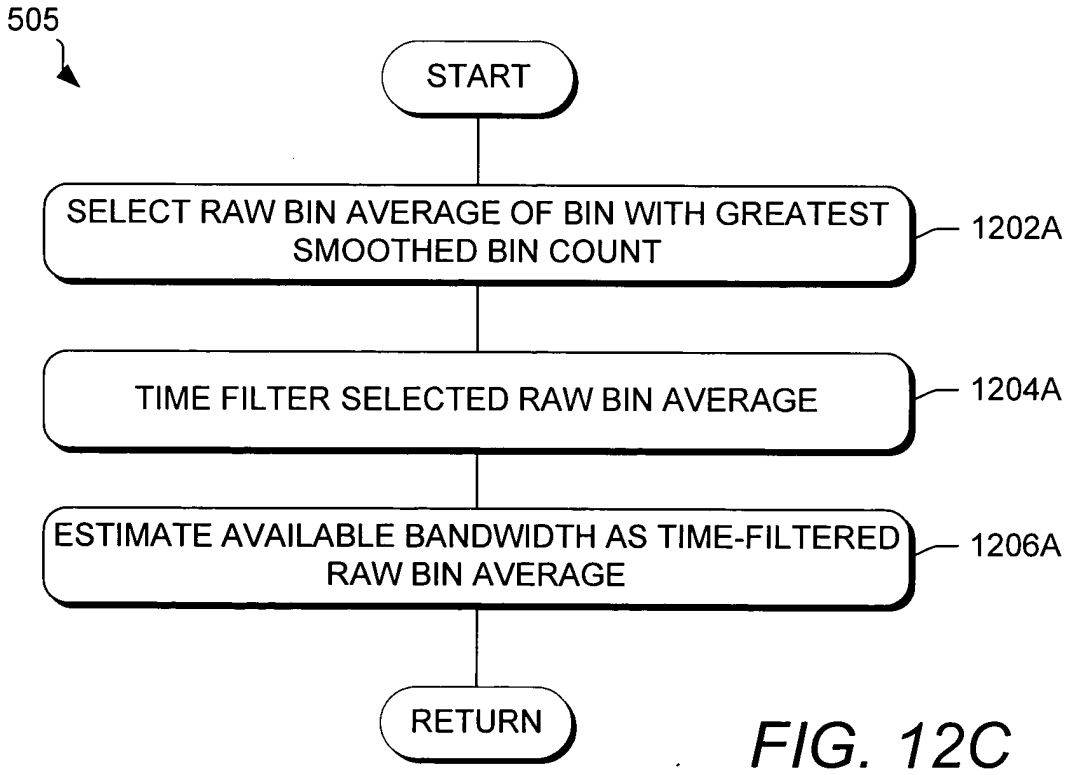

FIG. 12C

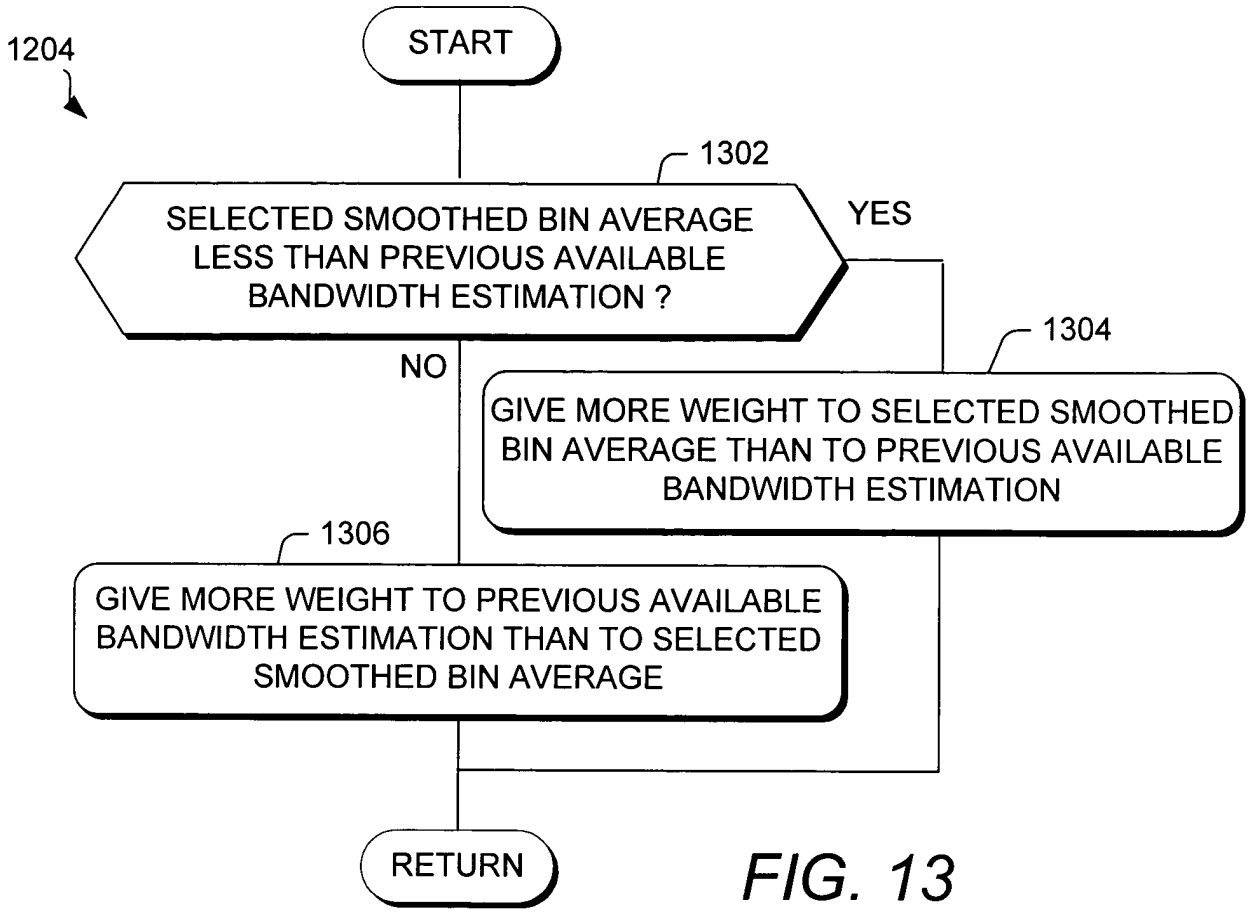
1204
START
1302
SELECTED SMOOTHED BIN AVERAGE LESS THAN PREVIOUS AVAILABLE BANDWIDTH ESTIMATION ?
YES
NO
1304
GIVE MORE WEIGHT TO SELECTED SMOOTHED BIN AVERAGE THAN TO PREVIOUS AVAILABLE BANDWIDTH ESTIMATION
1306
GIVE MORE WEIGHT TO PREVIOUS AVAILABLE BANDWIDTH ESTIMATION THAN TO SELECTED SMOOTHED BIN AVERAGE
RETURN

FIG. 13

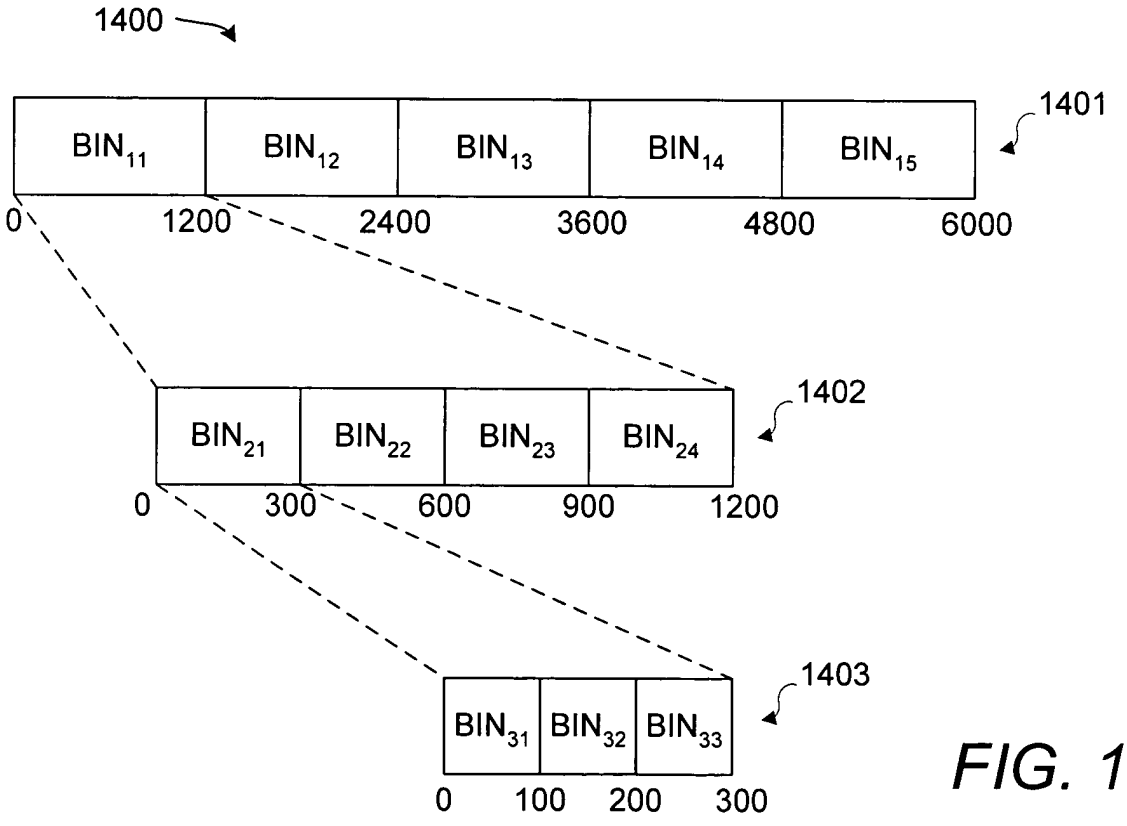
1400
BIN11
BIN12
BIN13
BIN14
BIN15
1401
0
1200
2400
3600
4800
6000
BIN21
BIN22
BIN23
BIN24
1402
0
300
600
900
1200
BIN31
BIN32
BIN33
1403
0
100
200
300

FIG. 14

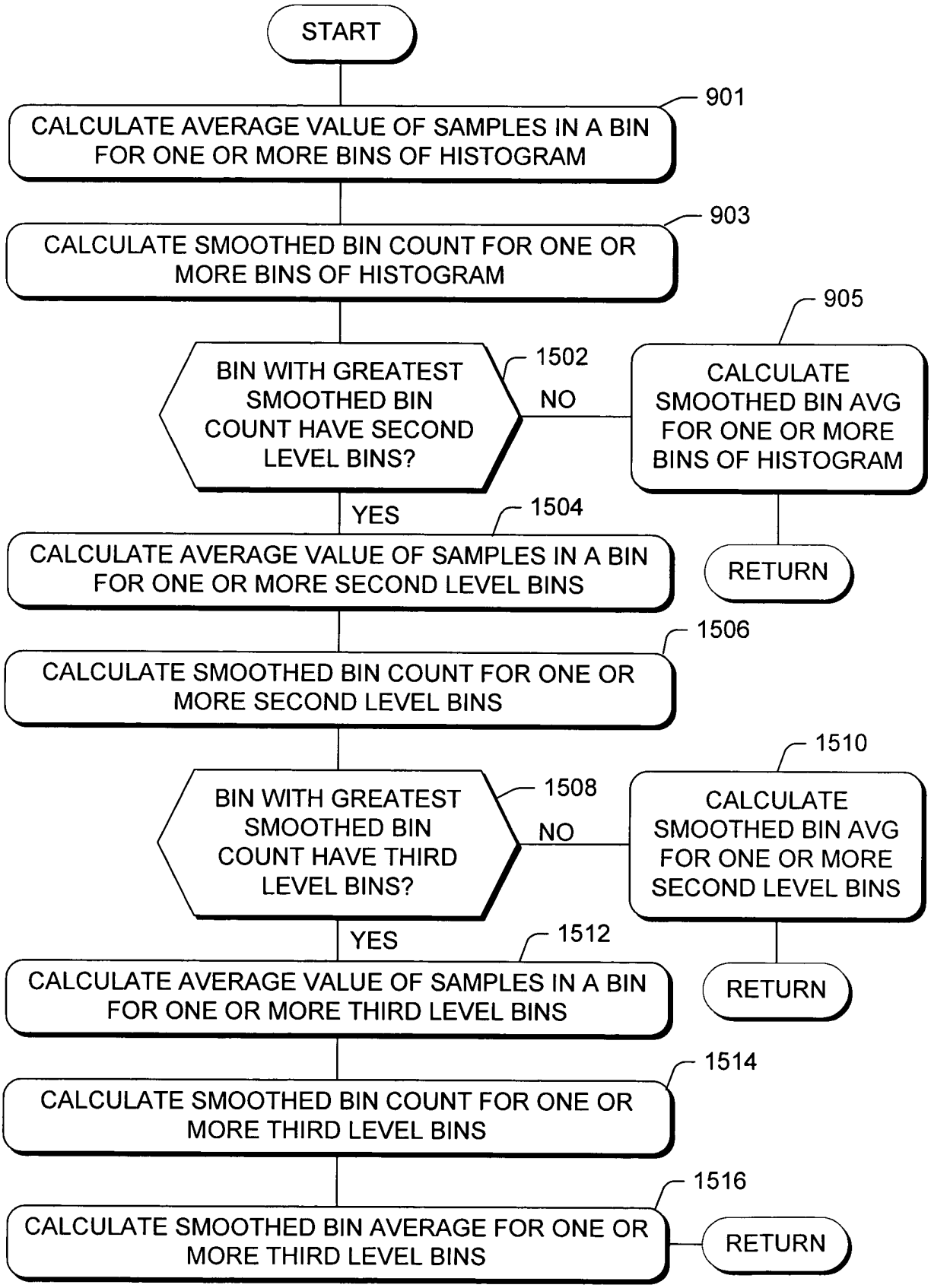
START
CALCULATE AVERAGE VALUE OF SAMPLES IN A BIN FOR ONE OR MORE BINS OF HISTOGRAM
901
CALCULATE SMOOTHED BIN COUNT FOR ONE OR MORE BINS OF HISTOGRAM
903
BIN WITH GREATEST SMOOTHED BIN COUNT HAVE SECOND LEVEL BINS?
1502
NO
CALCULATE SMOOTHED BIN AVG FOR ONE OR MORE BINS OF HISTOGRAM
905
YES
1504
CALCULATE AVERAGE VALUE OF SAMPLES IN A BIN FOR ONE OR MORE SECOND LEVEL BINS
RETURN
CALCULATE SMOOTHED BIN COUNT FOR ONE OR MORE SECOND LEVEL BINS
1506
BIN WITH GREATEST SMOOTHED BIN COUNT HAVE THIRD LEVEL BINS?
1508
NO
CALCULATE SMOOTHED BIN AVG FOR ONE OR MORE SECOND LEVEL BINS
1510
YES
1512
CALCULATE AVERAGE VALUE OF SAMPLES IN A BIN FOR ONE OR MORE THIRD LEVEL BINS
RETURN
CALCULATE SMOOTHED BIN COUNT FOR ONE OR MORE THIRD LEVEL BINS
1514
CALCULATE SMOOTHED BIN AVERAGE FOR ONE OR MORE THIRD LEVEL BINS
1516
RETURN

FIG. 15

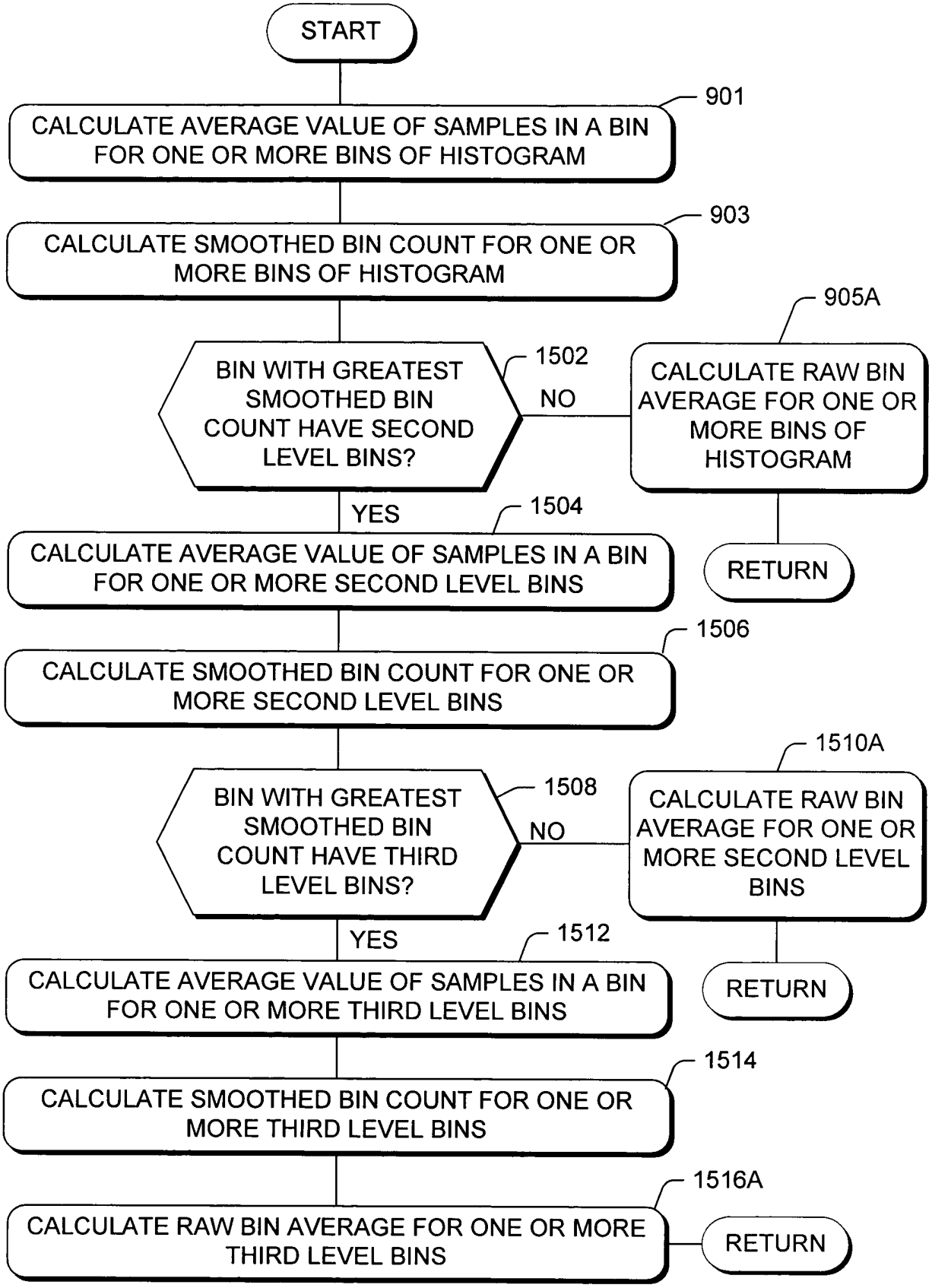
START
CALCULATE AVERAGE VALUE OF SAMPLES IN A BIN FOR ONE OR MORE BINS OF HISTOGRAM
901
CALCULATE SMOOTHED BIN COUNT FOR ONE OR MORE BINS OF HISTOGRAM
903
BIN WITH GREATEST SMOOTHED BIN COUNT HAVE SECOND LEVEL BINS?
1502
NO
905A
CALCULATE RAW BIN AVERAGE FOR ONE OR MORE BINS OF HISTOGRAM
YES
1504
CALCULATE AVERAGE VALUE OF SAMPLES IN A BIN FOR ONE OR MORE SECOND LEVEL BINS
RETURN
CALCULATE SMOOTHED BIN COUNT FOR ONE OR MORE SECOND LEVEL BINS
1506
BIN WITH GREATEST SMOOTHED BIN COUNT HAVE THIRD LEVEL BINS?
1508
NO
1510A
CALCULATE RAW BIN AVERAGE FOR ONE OR MORE SECOND LEVEL BINS
YES
1512
CALCULATE AVERAGE VALUE OF SAMPLES IN A BIN FOR ONE OR MORE THIRD LEVEL BINS
RETURN
CALCULATE SMOOTHED BIN COUNT FOR ONE OR MORE THIRD LEVEL BINS
1514
CALCULATE RAW BIN AVERAGE FOR ONE OR MORE THIRD LEVEL BINS
1516A
RETURN

FIG. 15A

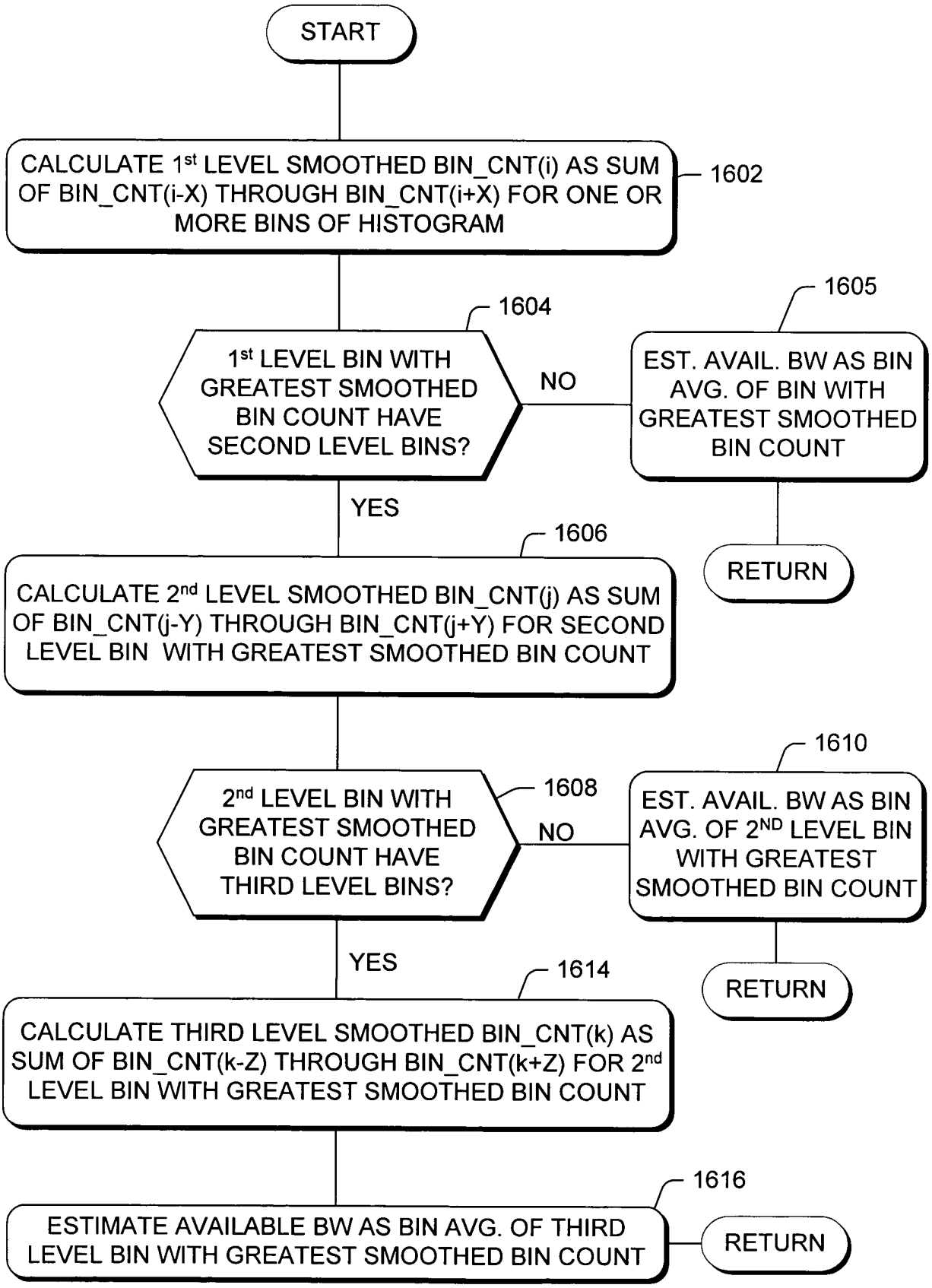
START
CALCULATE 1st LEVEL SMOOTHED BIN_CNT(i) AS SUM OF BIN_CNT(i-X) THROUGH BIN_CNT(i+X) FOR ONE OR MORE BINS OF HISTOGRAM
1602
1604
1st LEVEL BIN WITH GREATEST SMOOTHED BIN COUNT HAVE SECOND LEVEL BINS?
NO
1605
EST. AVAIL. BW AS BIN AVG. OF BIN WITH GREATEST SMOOTHED BIN COUNT
RETURN
YES
1606
CALCULATE 2nd LEVEL SMOOTHED BIN_CNT(j) AS SUM OF BIN_CNT(j-Y) THROUGH BIN_CNT(j+Y) FOR SECOND LEVEL BIN WITH GREATEST SMOOTHED BIN COUNT
1608
2nd LEVEL BIN WITH GREATEST SMOOTHED BIN COUNT HAVE THIRD LEVEL BINS?
NO
1610
EST. AVAIL. BW AS BIN AVG. OF 2ND LEVEL BIN WITH GREATEST SMOOTHED BIN COUNT
RETURN
YES
1614
CALCULATE THIRD LEVEL SMOOTHED BIN_CNT(k) AS SUM OF BIN_CNT(k-Z) THROUGH BIN_CNT(k+Z) FOR 2nd LEVEL BIN WITH GREATEST SMOOTHED BIN COUNT
1616
ESTIMATE AVAILABLE BW AS BIN AVG. OF THIRD LEVEL BIN WITH GREATEST SMOOTHED BIN COUNT
RETURN

FIG. 16

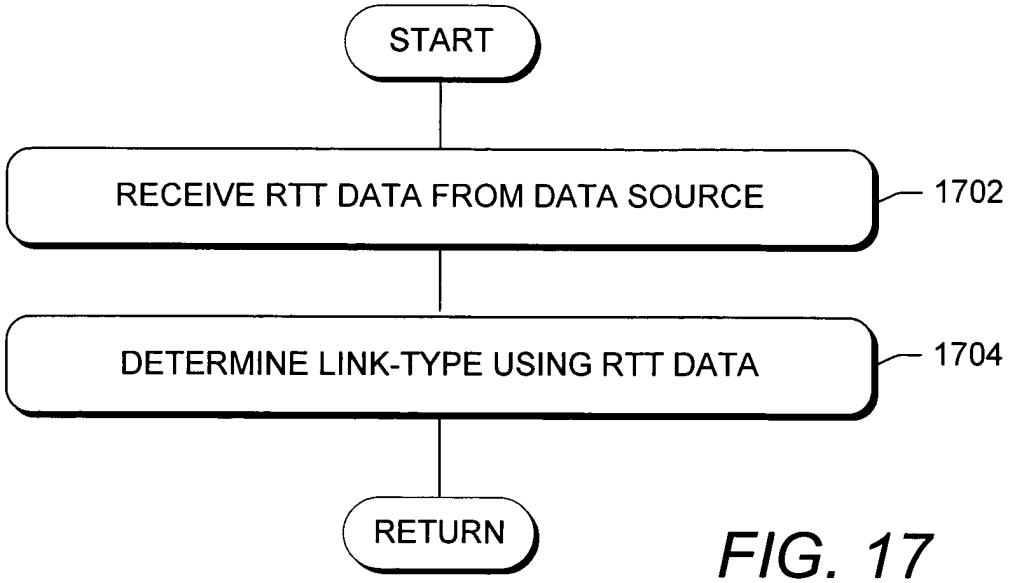
START
RECEIVE RTT DATA FROM DATA SOURCE
1702
DETERMINE LINK-TYPE USING RTT DATA
1704
RETURN

FIG. 17

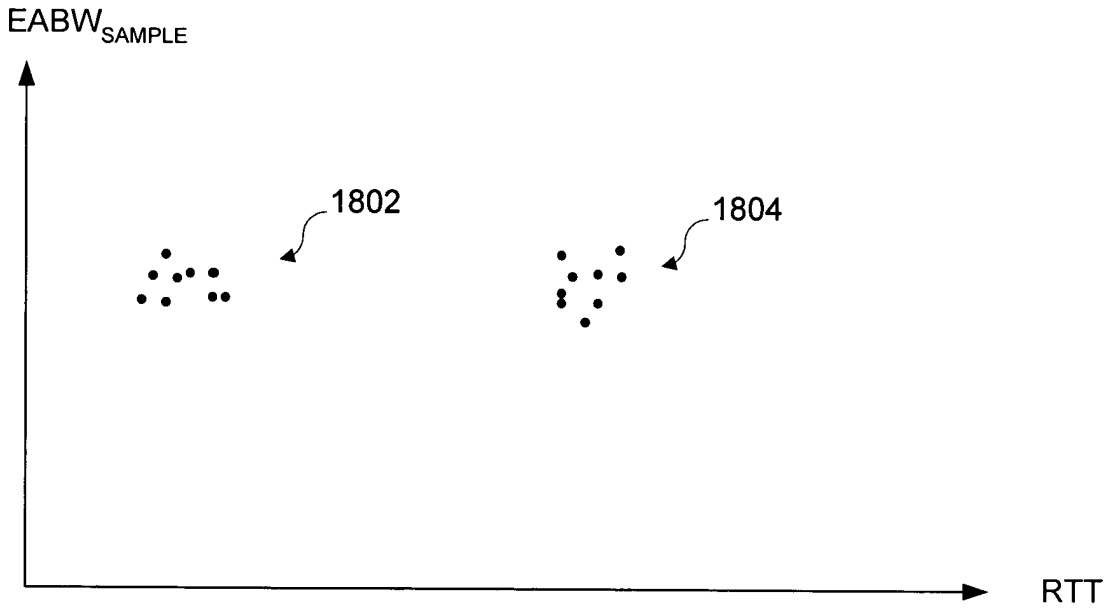
EABW$_{SAMPLE}$
1802
1804
RTT

FIG. 18